

WHAT IS CLAIMED IS:

1. A light-emitting diode (LED) device, comprising:
 - a substrate;
 - a first semiconductor layer, formed on top of the substrate;
 - an insulating layer, formed on top of the first semiconductor layer;
 - a mesa area, formed on the insulating layer and exposing the surface of the first semiconductor layer; and
 - an LED structure formed on the exposed surface of the first semiconductor layer;where the LED structure being a light-emitting active layer and a p-type GaN III-V group compound layer, the p-type GaN III-V group compound layer being connected to a p-type low-resistance ohm contact, and an n-type GaN III-V group compound layer being connected to an n-type low-resistance ohm contact to provide a forward bias.
2. The LED device as claimed in Claim 1, wherein the substrate is selected from the group consisting of sapphire, SiC, Si, GaAs, LiAlO₂, LiGaO₂, AlN.
3. The LED device as claimed in Claim 1, wherein the first semiconductor layer is an n-type semiconductor layer.
4. The LED device as claimed in Claim 1, wherein the first semiconductor layer is an Al_xGa_(1-x-y)In_yN thick film, with $0 \leq x, y < 1$, $0 \leq x + y < 1$.
5. The LED device as claimed in Claim 1, wherein the insulating layer at least comprises a material selected from a group consisting of SiO₂, SiN, AlN, TiN, Al₂O₃ and a combination thereof.
6. The LED device as claimed in Claim 1, wherein the insulating layer is made of metal, alloy, or their combination.

7. The LED device as claimed in Claim 1, wherein the insulating layer is fabricated with an e-gun, sputter, or CVD method.
8. The LED device as claimed in Claim 1, wherein the insulating layer has the thickness greater than $0.1\mu\text{m}$.
9. The LED device as claimed in Claim 1, wherein the mesa area is formed with a photo-lithography process.
10. The LED device as claimed in Claim 1, wherein the light-emitting active layer is a P-N junction, DH, SQW, or MQW structure.
11. A light-emitting diode (LED) device, comprising:
 - a substrate;
 - a first semiconductor layer, formed on top of the substrate;
 - a plurality of trenches, formed in a part of area of the first semiconductor layer;
 - an insulating layer, formed in the trenches; and
 - an LED structure formed on the exposed surface of the first semiconductor layer;where the LED structure being a light-emitting active layer and a p-type GaN III-V group compound layer, the p-type GaN III-V group compound layer being connected to a p-type low-resistance ohm contact, and an n-type GaN III-V group compound layer being connected to an n-type low-resistance ohm contact to provide a forward bias.
12. The LED device as claimed in Claim 11, wherein the substrate is selected from a group consisting of sapphire, SiC, Si, GaAs, LiAlO₂, LiGaO₂, AlN.
13. The LED device as claimed in Claim 11, wherein the first semiconductor layer is an Al_xGa_(1-x-y)In_yN thick film, with $0 \leq x, y < 1$, $0 \leq x + y < 1$.
14. The LED device as claimed in Claim 11, wherein the first semiconductor layer has the thickness greater than $0.1\mu\text{m}$.

15. The LED device as claimed in Claim 11, wherein the method of forming the trenches on the first semiconductor layer comprises at least one of the following methods: photo-lithography or laser processing.
16. The LED device as claimed in Claim 11, wherein the method of forming the trenches on the first semiconductor layer comprises at least one of the following methods: wet etching or dry etching.
17. The LED device as claimed in Claim 11, wherein the depth of the trenches on the first semiconductor layer is less than or equal to the thickness of the first semiconductor layer.
18. The LED device as claimed in Claim 11, wherein the depth of the trenches on the first semiconductor layer is greater than the thickness of the first semiconductor layer.
19. The LED device as claimed in Claim 11, wherein the shape of the trenches on the first semiconductor layer comprises at least one of the following or their combination: rectangle, triangle, circle, and polygon.
20. The LED device as claimed in Claim 11, wherein the insulating layer is selected from a group consisting of SiO_2 , Si_3N_4 , AlN , TiN , TiO_2 and a combination thereof.
21. The LED device as claimed in Claim 11, wherein the insulating layer is made of metal, alloy, or their combination.
22. The LED device as claimed in Claim 11, wherein the insulating layer has the thickness greater than $0.01\mu\text{m}$.
23. The LED device as claimed in Claim 11, wherein the light-emitting active layer is a P-N junction, DH, SQW, or MQW structure.